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Oldest Known Engelmann Spruce

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Age structure in a stand of very old-age Engelmann spruce is described. The site is at 3,505 m near treeline in the Fraser Experimental Forest in central Colorado. The site contains the oldest Engelmann spruce trees yet reported in the literature; the oldest tree is at least 852 years of age.

Keywords: dendrochronology, old-age, old growth, *Picea engelmannii*, tree rings

Introduction

The use of annual ring width and density chronologies from Engelmann spruce (*Picea engelmannii* (Parry) Engelm.) tree rings for climate reconstruction is well established (Parker and Henoch 1971, Kienast and Schweingruber 1986, Briffa et al. 1992). These studies show that ring widths and maximum latewood densities in Engelmann spruce tree rings can reflect annual or seasonal temperature variations. And while much is known about patterns of community dynamics and stand structure in Engelmann spruce/subalpine fir (*Abies lasiocarpa* (Hook) Nutt.) ecosystems in the central Rocky Mountains (e.g., Veblen 1986, Aplet et al. 1988, Veblen et al. 1991, Rebertus et al. 1992, Roovers and Rebertus 1993, Veblen et al. 1994), little is known about maximum age structure in these forests (Rebertus et al. 1992).

Here we report results of tree-ring research at a subalpine forest stand near upper treeline at the Fraser Experimental Forest in the central Rocky Mountains, Colorado. We have found several trees exceeding 500 years of age, including five trees over 680 years old and one that was at least 852 years old. The site of this oldest known Engelmann spruce may offer a record of more than 700 years of climate fluctuations in the central Rocky Mountains. It can also give insights into the age structure and long-term dynamics of a very old-age Engelmann spruce stand.

Study Area and Methods

The site sampled, FCC (Fool Creek Chronology), is located at approximately 3,505 m elevation and 10 to 30 m below treeline at the head of the Fool Creek drainage on the eastern edge of the Fraser Experimental Forest (figure 1). Site aspect is to the east, with a slope of 5° to 15°. The stand is relatively open, composed almost entirely of overstory Engelmann spruce

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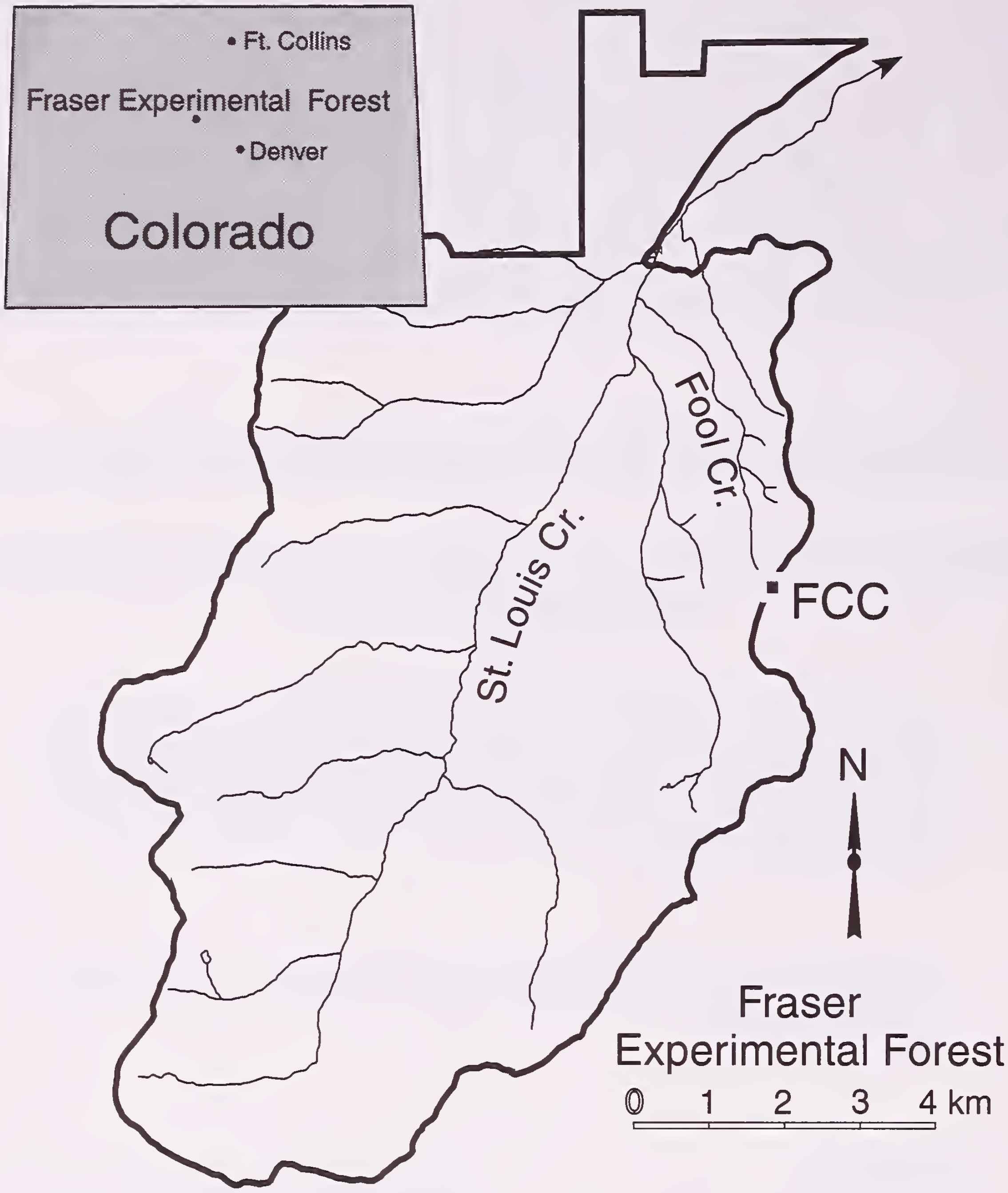

Figure 1.—Map of Fraser Experimental Forest and location of Fool Creek Chronology site.

with little subalpine fir or understory trees of other species (figure 2). Ground cover at the site is dominated by *Vaccinium* spp.

Living trees were sampled using increment borers with a minimum of two cores removed per tree. Cores were generally taken at or just below breast height, although if decay was encountered on the first core, subsequent cores were taken as high on the stem as possible. Tree selection within the stand was based upon old-age characteristics such as large diameter, exaggerated stem taper, dead tops, evident spiral grain in the bark, and large branches. Downed logs were also sampled with increment borers or had cross sections cut with either chainsaws or crosscut saws.

Samples were prepared, sanded, and crossdated using standard dendrochronological procedures (Stokes and Smiley 1968, Swetnam et al. 1985). Crossdating relied upon visually matching patterns in both ring widths and characteristics of annual latewood bands such as thickness and darkness. Once crossdated, ring widths were measured to 0.01 mm precision using a moveable stage connected to a computer through a rotary shaft encoder/translator mechanism. A ring width chronology was developed for the site using program CRONOL (R.L. Holmes, unpublished). Ring width series were first detrended (Fritts 1976) using either a negative exponential curve (Fritts et al. 1969) or straight line constrained to flat or negative slope. Detrending involved dividing each yearly ring width by the corresponding curve or line fitted value to form a dimensionless index series with stable mean and variance (ring index). Yearly ring width indices from each core were then combined into a chronology using a biweight robust mean (Cook 1985).

Figure 2.—A portion of the Fool Creek Chronology site. All of the trees in this view are *Picea engelmannii*.

Results and Discussion

A total of 78 trees was sampled at the site. The ring width chronology for the site is shown in figure 3. This chronology, coupled with other chronologies of ring density that are to be developed from these samples, will form the basis for a long-term climatic reconstruction for this area.

Time spans of the tree ring series used in the chronology are shown in figure 4. Note in figure 4 that several of the samples ended in decayed centers, making accurate age estimates of these trees problematic. In addition, none of the inside dates shown in figure 4 is an establishment date since samples were generally removed from near breast height or above. However, assuming similar time to reach breast height on each tree in the stand, it appears that at least from the late 1300s to the early 1800s, recruitment within the stand may have been approximately continuous, with pith or near-pith dates (estimated to be within 10 years of the pith) scattered throughout this period.

In the earliest portion of the chronology, the distribution of inside dates appears to be more grouped (figure 4). There appears to be a very old-age cohort at the site that was followed by a hiatus from the early to the late 1300s with no center dates. The oldest tree at the site (FCC 19) did not have a decayed center and the time span covered by this tree was from AD 1142 to 1993. This is the oldest Engelmann spruce yet reported in the literature (table 1). Sample FCC 78 was from a log and has the second oldest inside date at the site, 1224. This date is from a cross section taken within 0.3 m of the base of the tree, and is fairly close to the pith (estimated to be within 20 years). Five samples have inside dates in the early to mid-1200s that are either pith or near pith dates (FCC 78, FCC 24, FCC 58, FCC 42 and FCC 67; table 2). Four other trees have inside dates in the period from the late 1290s to the early 1310s that end in decay (FCC 22, FCC 37, FCC 20, and FCC 43; table 2). This latter group of trees may have also originated in the early 1200s, suggesting a stand-initiating event sometime before this period.

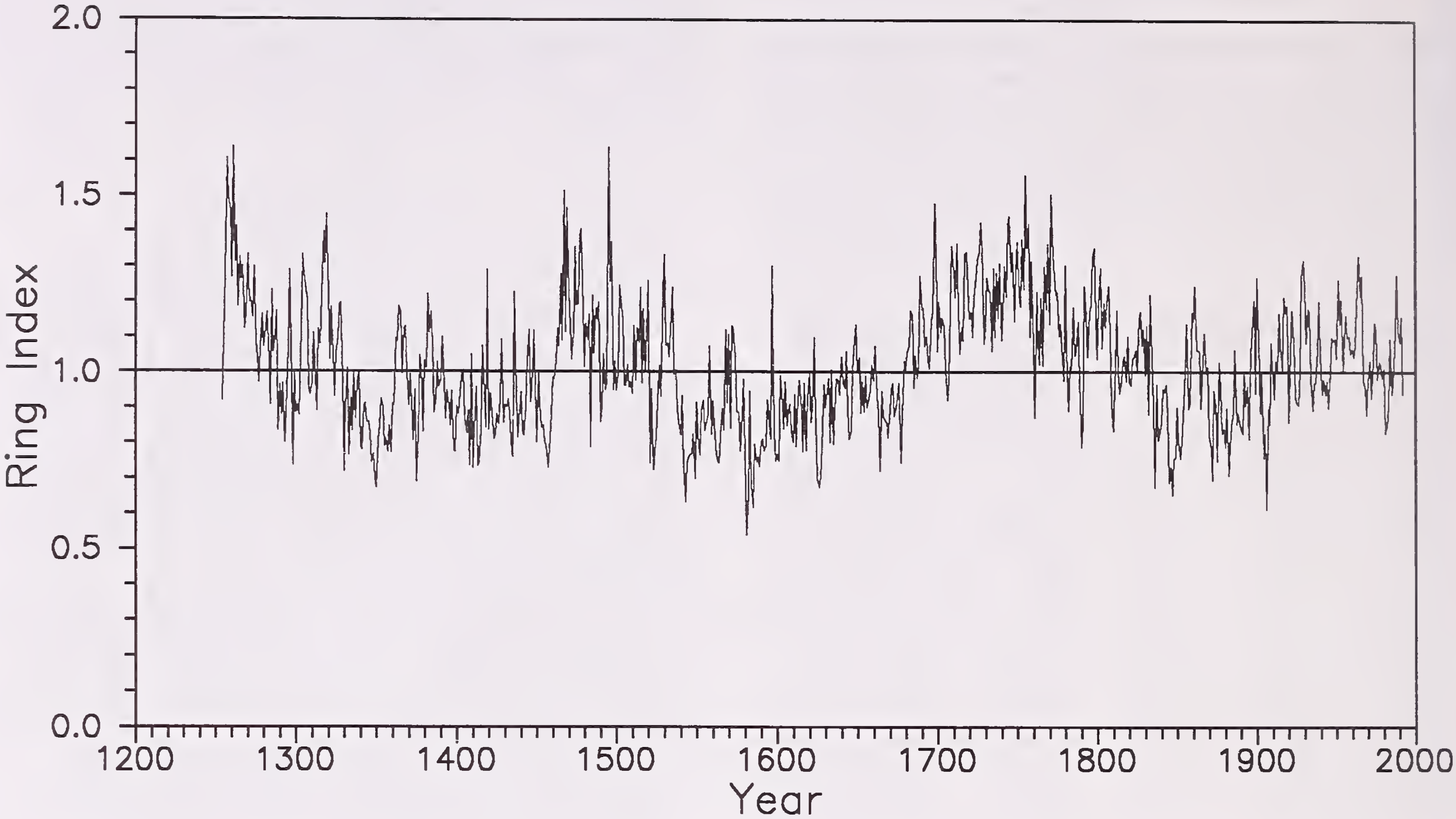

Figure 3.—Ring width chronology from the Fool Creek Chronology site.

This distribution of inside dates at FCC would appear to support the hypothesis of Aplet et al. (1988) that spruce recruitment in a stand may be discontinuous. By looking at a chronosequence of spruce-fir sites, Aplet et al. (1988) suggested that after a stand-reinitiating disturbance such as fire occurs, rapid spruce recruitment is followed by a period of spruce exclusion. They suggest that the initial period of recruitment may last 100 to 250 years, while the period of exclusion lasts approximately 100 years. A second wave of spruce establishes 200 to 350 years after the original disturbance event as many of the original pioneer individuals die off and small-scale gap formation increases. While Rebertus et al. (1992) point out that this pattern of spruce recruitment/exclusion/recruitment is not uniform in all cases in subalpine forests of the central Rocky Mountains, the preliminary evidence from the FCC site suggests that this may have been the early pattern in this stand.

Table 1.—Maximum ages reported for Englemann spruce trees.

Age (years)	Location	Reference
295	Pinaleño Mountains, Arizona	Swetnam and Brown 1992
408	Eastern British Columbia	Bray 1964
460	Rocky Mountain Nat'l Park, Colorado	Veblen, et al. 1991
547	Bowen Gulch, Colorado	Roovers and Rebertus 1993
625	Cache La Poudre-Laramie Rivers, Colorado	Aplet et al. 1988
680	Jasper Nat'l Park, Alberta	Luckman et al. 1984[1]
760	Peyto Glacier, Alberta	B.H. Luckman (pers. corres.)
852	Fraser Experimental Forest, Colorado	this report

[1] Luckman et al. (1984) also list several other studies reporting maximum ages for Engelmann spruce.

Conclusions

Tree-ring records that are both long and climatically responsive are specifically targeted by U.S. and international efforts as sources of information on past environmental and climatic change on the planet (National Research Council 1990). Future work at this site will explore stand structural history and seek to reconstruct past climate. More remnant (dead) material will be collected to possibly extend the FCC chronology further into the past and develop ring density chronologies. Work will also examine other stands in this area to see if other old-age trees are present.

Table 2.—Oldest inside dates at Fool Creek Chronology site.

Sample ID	Type of sample	Beginning year	Type of inside date	Ending year	Age
FCC 19	Living	1142	Pith	1993	852
FCC 78	Log	1224	Near pith	1705	482
FCC 24	Living	1236	Near pith	1993	758
FCC 58	Living	1241	Pith	1994	754
FCC 42	Log	1250	Pith	1843	594
FCC 67	Log	1254	Pith	1783	530
FCC 22	Living	1298	Decay	1993	696
FCC 37	Living	1300+	Decay	1993	694+
FCC 18	Log	1306	Near pith	1767	462
FCC 20	Living	1313	Decay	1993	681
FCC 43	Log	1314	Decay	1866	553

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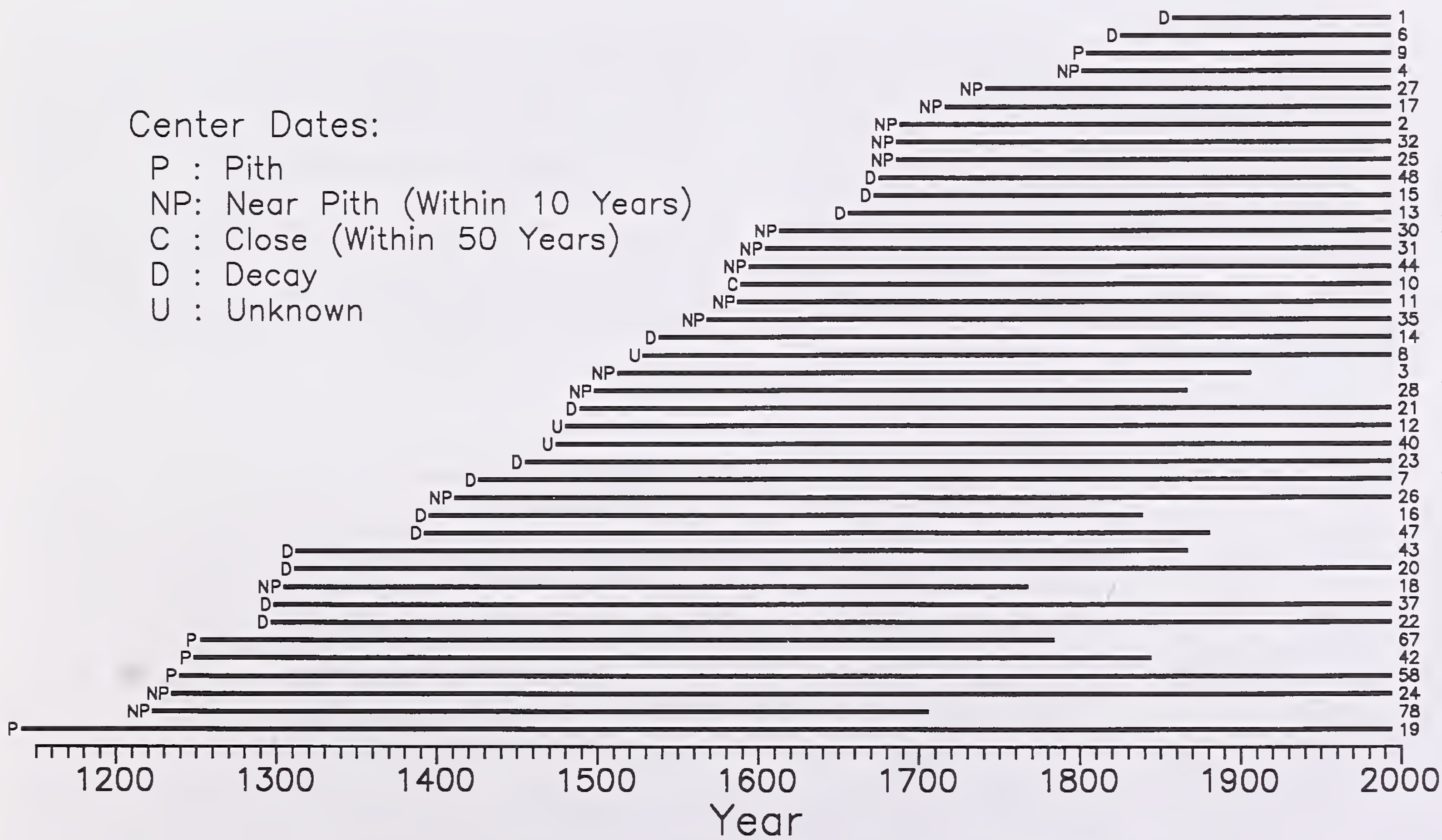

Figure 4.—Time spans of individual trees at the Fool Creek Chronology site.

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